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# Immigration of Amoeboceratids into the Submediterranean Upper Jurassic of SW Germany

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**Abstract:** During the Late Jurassic, Southern Germany was part of the Submediterranean Faunal Province. Several ammonite faunal horizons within the rock sequence, however, yield remarkable numbers of amoeboceratids which are of great importance for correlations between the Tethyan Standard Zones and zonal schemes of Subboreal and Boreal areas. Based on the succession of amoeboceratid biochronospecies in Southern Germany, such correlation is possible for the stratigraphic interval between the Middle Oxfordian Transversarium Zone and the Upper Kimmeridgian Acanthicum Zone of the Tethyan standard.

## Introduction

Different Upper Jurassic zonal schemes exist for the Tethyan Realm and the more northerly areas of Europe in order to deal with strong bioprovincialism. During the last two decades several efforts have been made to correlate these zonal schemes (Sykes and Callomon, 1979; Matyja and Wierzbowski, 1988). In principle, correlation is possible using Boreal faunal elements which also occur in adjacent parts of the Tethyan Realm. One of the most important ammonite groups for such correlations are the amoeboceratids. While some efforts have been made to analyse the occurrence of amoeboceratids in the Submediterranean Upper Jurassic of E France, N Switzerland and central Poland (Atrops et al., 1993), the exact succession of amoeboceratid biochronospecies in SW Germany remained unknown, although several important species names are based on specimens from there. It is the purpose of this paper to give a brief overview on the state of knowledge in SW Germany (Fig. 1) based on new bed-by-bed collections and additional material from older collections.

## Amoeboceratids of the Middle and Late Oxfordian

In the westernmost part of Swabia (Wutach area) and in adjacent parts of Switzerland, the Upper Jurassic begins with a succession of three thin lithostratigraphic members, the "Glaukonitsandmergel" (Cordatum Zone) at the base, followed by the very condensed "Mumienmergel" and an approximately 20 cm thick glauconitic limestone bed in which siliceous sponges accompanied by thrombolithic microbial crusts occur for the first time (Gygi, 1977). The latter, known as "Mumienkalk", is very rich in ammonites which have not yet been described as a whole. In the "Mumienkalk", Submediterranean perisphinctids such as *Subdiscosphinctes elisabethae* (De Riaz) are very common, together with rare macroconchs such as the subzonal index species *Perisphinctes parandieri* (Loriol) (Transversarium Zone, Parandieri Subzone). In contrast to the very condensed and partly reworked glauconitic "Mumienmergel" of the Plicatilis Zone (Antecedens Subzone) below, where cardioceratids are abundant, in the overlying Parandieri Subzone the large majority of ammonites consists of Mediterranean faunal elements: *Ochetoceras canaliculatum* (Buch), *Glochiceras subclausum* (Oppel), *Trimarginites trimarginatus* (Oppel), *Trimarginites arolicus* (Oppel), *Neomorphoceras collinii* (Oppel), *Taramelliceras bachianum* (Oppel), *Taramelliceras semiplanum* (Oppel). Even such typical Tethyan elements as *Gregoryceras riazi* (De Grossouvre), *Sowerbyceras* sp., *Holcophylloceras manfredi* (Oppel) and *Lissoceratoides erato* (d'Orbigny) are recorded from this level; *Gregoryceras riazi* is relatively common at this

level (Gygi, 1977). Its intraspecific variability suggests a possible synonymy both with *G. transversarium* (Quenstedt) and with *G. toucasianum* (d'Orbigny). Besides these Tethyan elements, very rarely the first macroconch amoeboceratids occur. They have been identified as *Amoeboceras ilovaiskii* (Sokolov) (Pl. 1.1-2) and *Amoeboceras transitorium* Spath (Pl. 1.3). Due to their rarity, it is uncertain whether these forms are really two different biospecies occurring together, or whether they represent different morphological varieties within a single biochronospecies. Microconch amoeboceratids have not yet been recorded, a striking difference compared to higher levels, where microconchs are predominant. However, correlation is possible with the Glosense Zone of Great Britain, in which identical amoeboceratids occur (Wright, 1996).

| Submediterranean Zonation | | *Amoeboceras* chronospecies | Subboreal / Boreal Zonations | |
|---|---|---|---|---|
| Acanthicum | | *E. kochi* | Mutabilis | Kochi |
| | | *E. modestum* | | |
| Divisum | | | Cymodoce | Kitchini |
| Hypselocyclum | | | | |
| Platynota | | | | |
| | Polygyratus | *A. subtilicaelatum* | | |
| Planula | Galar | | | |
| | Planula | *A. haizmanni* | Baylei | Bauhini |
| Bimammatum | Hauffianum | *A. bauhini* | | |
| | Bimammatum | *A. praebauhini* | Pseudo-cordata | Rosen-krantzi |
| | Hypselum | *A. ovale* | | Regulare |
| Bifurcatus | Grossouvrei | *A. alternans* | Cautisnigrae | Serratum |
| | Stenocycloides | | | |
| Transversarium | Rotoides | | Pumilus | Glosense |
| | Schilli | | | |
| | Luciaeformis | | | |
| | Parandieri | *A. transitorium* *A. ilovaiskii* | | |

Figure 1. Submediterranean ammonite zonation compared to Subboreal/Boreal zonations. This correlation is mainly based on amoeboceratid biochronospecies from the Upper Jurassic of SW Germany.

In the following beds of the Transversarium Zone, amoeboceratids and other Boreal or Subboreal faunal elements are rare. They reappear in the upper part of the Bifurcatus Zone (not investigated in detail so far) and also at the base of the Bimammatum Zone (Hypselum Subzone, *semimammatum* faunal horizon). At these levels, microconch amoeboceratids are very common, especially adjacent to small sponge bioherms, whereas adult macroconch amoeboceratids are nearly absent. A fragmentary macroconch *Amoeboceras* of the *regulare* group, from the *semimammatum* horizon of Franconia, was named "*Cardioceras*" *neischli* (see Dorn, 1930, Pl. 18, Fig. 28). The microconchs may be identified as *Amoeboceras alternans* (Buch) (Pl. 1-4) or *Amoeboceras ovale* (Quenstedt) (Pl. 1.5). The neotype and lectotype specimens of both morphospecies may come from the same faunal horizon at the foot of the "Lochen" hill near Balingen (Western Swabian Alb), thus representing morphological varieties of the same biochronospecies. It can be noted, however, that specimens with a more coarsely ribbed *alternans* sculpture are more typical in the Bifurcatus Zone. The immigration of amoeboceratids coincides exactly with the initial growth of siliceous sponge

mud mounds in the Swabian Jurassic ("Lochen Spongiolithic Limestones"). Another Subboreal influx is demonstrated by the occurrence of the ammonite genus *Ringsteadia* (*R. salfeldi* Dorn) together with its microconch counterpart *Microbiplices/Prorasenia* and the byssate bivalve *Buchia concentrica* (Sowerby). Levels with amoeboceratids are often glauconitic. The glauconitic *semimammatum* horizon with exactly the same ammonite faunal composition is also known from Franconia (Gräfenberg quarry). The following *berrense* faunal horizon of the Hypselum Subzone, mainly characterised by its index *Epipeltoceras berrense* (Favre), contains few ammonites. Only a few records of amoeboceratids are indicated from this level: an unnamed *Amoeboceras* species with bi- and trifurcating secondaries (Pl. 1.6).

In the middle part of the Bimammatum Zone (*bimammatum* faunal horizon) the ammonite fauna of SW Germany reached its greatest diversity during the whole of Oxfordian time. Tethyan faunal elements predominate in this horizon, but amoeboceratids also occur. Again, glauconitic layers are common. Most of the amoeboceratids belong to the microconch species *Amoeboceras praebauhini* (Salfeld) (Pl. 1.8). Just as in Central Poland (Matyja and Wierzbowski, 1988), the variability of this biochronospecies is remarkably high and includes specimens which are transitional to the younger biochronospecies *A. bauhini* (Oppel). This does not mean, however, that *A. bauhini* first appears already in the *bimammatum* horizon, so that its correlation value is well established. The corresponding macroconch of *A. praebauhini* is very close to, or identical with, *Amoeboceras rosenkrantzi* Spath, a species known from Greenland and other Boreal areas. The strange *Amoeboceras transversum* (Quenstedt) (Pl. 1.7, Fig. 2a) is interpreted as being a very coarse ribbed variant of *A. rosenkrantzi* (see Sykes and Callomon, 1979: Pl. 120.1). Adult macroconch amoeboceratids, however, are extremely rare. Other Subboreal elements at this level are *Ringsteadia flexuoides* (Quenstedt) which is close to *R. pseudocordata* Salfeld, and its microconch counterpart which belongs of the genus *Prorasenia*.

**Amoeboceratids from the Oxfordian/Kimmeridgian Boundary Beds**

In the western part of Swabia the top of the Bimammatum Zone is marked by a further glauconitic level, where ammonites are locally very abundant. In adjacent Switzerland, this bed partly coincides with the "Knollenschicht" of Moesch (see Gygi, 1969). In Swabia it yields the *bauhini* faunal horizon which is mainly characterised by its index species *Amoeboceras bauhini* (Oppel) (Pl. 1.9) together with the Tethyan index *Taramelliceras hauffianum* (Oppel). In the Subboreal succession in Great Britain, *A. bauhini* is indicative for the base of the Lower Kimmeridgian Baylei Zone (Schweigert, 1995, Schweigert and Callomon, 1997) associated with *Pictonia densicostata*. Similar results as in SW Germany have been obtained from central Poland (Matyja and Wierzbowski, 1997). Hence, the overlying Submediterranean Planula Zone falls completely into the Early Kimmeridgian according to the Subboreal zonal scheme. If we accept the traditional definition of the base of the Kimmeridgian in Great Britain as binding on the chronostratigraphic standard time scale, then the Planula Zone of the Submediterranean (Crussolian) standard zonation has to be included within the Kimmeridgian Stage (see Atrops *et al.*, 1998). *Amoeboceras bauhini* is accompanied by its extremely rare macroconch counterpart *Amoeboceras schulginae* Mesezhnikov (Pl. 1.10), but surprisingly another dimorphic pair also occurs, with the macroconch resembling *Euprionoceras* (Pl. 1.11). The best exposure which yields the fauna of the *bauhini* horizon and which is extremely rich in fossils, is the Plettenberg quarry near the town of Balingen.

The Planula Zone is characterised by a Submediterranean fauna comprising mainly perisphinctids (*Subnebrodites*) and oppeliids (*Metahaploceras*). Other ammonite groups occur only sporadically. Amoeboceratids are very rare in the Planula Subzone and at the beginning of the Galar Subzone. Most specimens look somewhat pathologic, with loss both of the keel and sculpture on the body chamber. Fischer (1913) described this strange *Amoeboceras* species as "*Cardioceras haizmanni*" (Pl. 1.12).

**Amoeboceratids from Kimmeridgian Beds of SW Germany**

In the upper part of the Galar Subzone and in the lowermost faunal horizon of the subsequent Platynota Zone, a last remarkable wave of microconch amoeboceratids swept into the Submediterranean Province, reaching even SE France (Atrops et al., 1993). Some coarser ribbed morphotypes have been misidentified as *A. bauhini* (Oppel) in the past (e. g. specimens like Pl. 1.13), but the retroradiate ribbing style of the latter is a good feature for easy distinction of *A. bauhini* from this younger form. A very fine-ribbed variety coming from this level gives the

chronospecific name: *Amoeboceras subtilicaelatum* (Fontannes) (Pl. 1.14). Macroconchs are close to *Amoeboceras bayi* Birkelund and Callomon (Fig. 2b). At higher levels, amoeboceratids are extremely rare in the Swabian Upper Jurassic, and most faunal horizons lack these boreal elements. A few specimens probably belonging to *Euprionoceras* cf. *modestum* Mesezhnikov and Romm (Pl. 1.15) are recorded from a level within the Late Kimmeridgian Acanthicum Zone. The youngest known *Amoeboceras* from Swabia is an immature macroconch of *Euprionoceras kochi* Spath (Pl. 1.16), coming from near the base of the Eudoxus Zone. The ammonite faunas of the Divisum and Acanthicum Zones in SW Germany are far from well-known. Hence, correlations at the base of ammonite faunal horizons are hardly possible, since a high resolution stratigraphy of this interval is still missing.

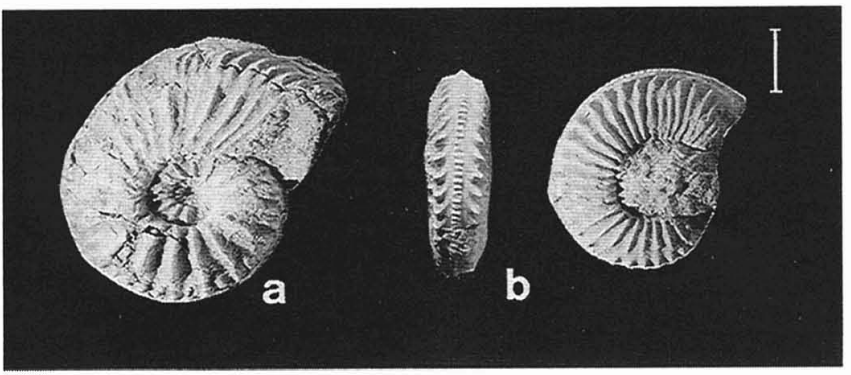


Figure 2. **a.** *Amoeboceras* cf. *rosenkrantzi* (= *Ammonites alternans* in Quenstedt, 1888, Pl. 91.25). Bimammatum Zone, Bimammatum Subzone, *bimammatum* horizon, Lochen area. **b.** *Amoeboceras bayi* Birkelund and Callomon. Platynota Zone, Polygyratus Subzone *sensu* Atrops, *subtilicaelatum* horizon. Aalen-Westhausen, SW Germany. SMNS (Stuttgart) No. 63645. – Scale bar 1 cm.

In Poland and in other Subboreal areas, amoeboceratids occur up to the Late Kimmeridgian Autissiodorensis Zone (Kutek and Zeiss, 1997). During this time, the Subboreal influx in southern Germany diminished, probably because of a change in patterns of marine currents and paleogeographic configurations in the area between Poland and Southern Germany. Thus, no amoeboceratid ammonites have been recorded so far from the late Eudoxus and Autissiodorensis Zones in southern Germany.

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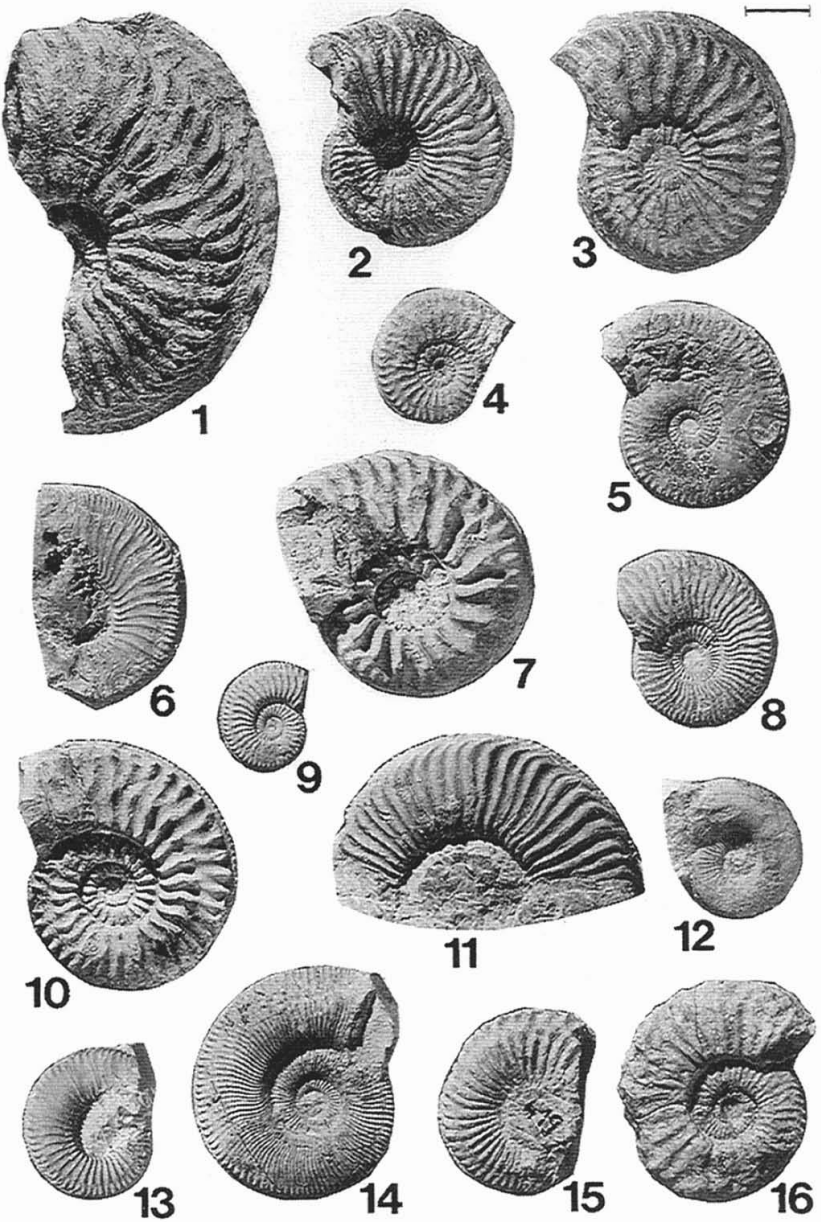
Plate 1. **1-2**. *Amoeboceras ilovaiskii* (Sokolov). Transversarium Zone, Parandieri Subzone, *elisabethae* horizon, "Mumienkalk" Bed, Blumberg, SW Germany. **1.** BSPM (Munich) No. 1950 XXX 111; **2.** SMNS (Stuttgart) No. 63643; **3**. *Amoeboceras transitorium* Spath. Transversarium Zone, Parandieri Subzone, *elisabethae* horizon, "Mumienkalk" Bed, Blumberg, SW Germany. SMNS (Stuttgart) No. 63644; **4**. *Amoeboceras alternans* (Buch). Bifurcatus Zone, Lochen Sponge Beds, Lochengründle near Balingen, SW Germany. SMNS (Stuttgart) No. 63640/1; **5**. *Amoeboceras ovale* (Quenstedt). Bimammatum Zone, Hypselum Subzone, *semimammatum* horizon, Lochen Sponge Beds, Lochengründle near Balingen, SW Germany. SMNS (Stuttgart) No. 63641/1; **6**. *Amoeboceras* sp. Bimammatum Zone, Bimammatum Subzone, *berrense* horizon, Impressamergel Formation, former Lochen quarry near Balingen. SMNS (Stuttgart) No. 63638; **7**. *Amoeboceras transversum* (Quenstedt), probably a very coarse ribbed variant of *A.* cf. *rosenkrantzi* (Spath). Bimammatum Zone, Bimammatum Subzone, *bimammatum* horizon. Lochen Sponge Beds, Lochengründle near Balingen, SW Germany. SMNS (Stuttgart) No. 14353; **8**. *Amoeboceras praebauhini* (Salfeld). Bimammatum Zone, Bimammatum Subzone, *bimammatum* horizon, Impressamergel Formation, Mühlheim/Donau, SW Germany. SMNS (Stuttgart) No. 23276; **9**. *Amoeboceras bauhini* (Oppel). Bimammatum Zone, Hauffianum Subzone, *bauhini* horizon, transitional beds between Impressamergel Formation and Wohlgeschichtete Kalk Formation, Plettenberg quarry, SW Germany. SMNS (Stuttgart) No. 62868/5; **10**. *Amoeboceras schulginae* Mesezhnikov. Hauffianum Subzone, *bauhini* horizon, transitional beds between Impressamergel Formation and Wohlgeschichtete Kalk Formation, Lochen quarry, SW Germany. SMNS (Stuttgart) No. 9716; **11**. ? *Euprionoceras* sp. Bimammatum Zone, Hauffianum Subzone, *bauhini* horizon, transitional beds between Impressamergel Formation and Wohlgeschichtete Kalk Formation, Plettenberg quarry, SW Germany. SMNS (Stuttgart) No. 62471; **12**. *Amoeboceras haizmanni* (Fischer). Planula Zone, Planula Subzone, probably *schroederi* horizon, Wohlgeschichtete Kalke Formation, Tuttlingen, SW Germany. SMNS (Stuttgart) No. 63636; **13**. *Amoeboceras subtilicaelatum* (Fontannes), coarsely ribbed variety. Planula Zone, Galar Subzone, *falcula* horizon, Wohlgeschichtete Kalke Formation, road section Mühlheim/Donau – Kolbingen, SW Germany. SMNS (Stuttgart) No. 63642; **14**. *Amoeboceras subtilicaelatum* (Fontannes), finely ribbed variety. Platynota Zone, Polygyratus Subzone, *subtilicaelatum* horizon, Lacunosamergel Formation, SW Germany. SMNS (Stuttgart) No. 63639; **15**. *Euprionoceras* cf. *modestum* Mesezhnikov and Romm. Untere Felsenkalke Formation, Acanthicum Zone, Stettener Tal near Tuttlingen, SW Germany. SMNS (Stuttgart) No. 63634; **16**. *Euprionoceras kochi* Spath. Eudoxus Zone, Untere Felsenkalke Formation, "Paradise cave", Lippachtal near Mühlheim/Donau, SW Germany. SMNS (Stuttgart) No. 63635. Scale bar 1 cm.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